SCIENCE

FRIDAY, JANUARY 1, 1897.

CONTENTS:

MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Prof. J. McKeen Cattell, Garrison-on-Hudson, N. Y.

*THE GEOLOGY OF GOVERNMENT EXPLORATIONS.**

I HAVE chosen for the subject of my address this evening the development of our knowledge of the geology of the great West through the agency of explorations and surveys conducted under government auspices.

To the older of our members, especially to those who took part in those early explorations, the matter may appear somewhat trite, but to the younger ones, whose geological memory does not go back beyond the present Survey, I have thought that it might be interesting to listen to a brief account of the origin and methods of work of these earlier organizations by one who was first connected with them very nearly thirty years ago.

The period to be considered commences about with the opening of the century, and is most naturally subdivided by the Civil War. But in this field, as in others, the accumulation of knowledge progresses with ever increasing rapidity, so that, while for the first and much longer sub-period it is possible to trace approximately the actual gains that were made in geological knowledge, in the second period it is only practicable to attempt to characterize and contrast the methods by which geological in-

* Address of the Retiring President of the Geological Society of Washington, delivered Wednesday, December 16, 1896.

vestigation was carried on. The first may be called the period of geographical exploration; the second that of geological exploration.

GEOGRAPHICAL EXPLORATIONS.

It was Jefferson's purchase of the Louisiana territory, in 1803, that gave to the United States government the first title to the Rocky Mountain region, but even prior to that time it appears that he had formed a project for its exploration. He tells us that in 1786, during his residence at Paris (as U. S. Minister) he met John Ledyard, of Connecticut, a companion of Captain Cook on his last voyage to the Pacific Ocean, who had just failed in the attempt to organize a mercantile company to engage in the fur trade on the western coast of America. Jefferson proposed to him 'to go by land to Kamchatka, cross in some of the Russian vessels to Nootka Sound, fall down into the latitude of the Missouri, and penetrate to and through that to the United States.' Ledyard eagerly embraced the idea, and after the permission to pass through her territory had been secured through Jefferson's influence, from the Empress of Russia, with an assurance of protection on his journey, he set forth from Paris and, proceeding via. St. Petersburg, had progressed to within 200 miles of Kamchatka, where he was obliged to go into winter quarters. When he was preparing to resume his journey in the spring he was arrested by an officer of the Empress (who by this time had changed her mind), put into a close carriage and conveyed, day and night without stopping, to the frontier of Poland. He returned to Paris much broken down in bodily health, and not long after (November 15, 1788) died at Cairo, Egypt, whither he had gone for the purpose of exploring the interior of Africa. Thus failed the first attempt at exploration.

1792. In 1792 Jefferson proposed to the American Philosophical Society at Philadelphia 'to set on foot a subscription to engage some competent person to explore that region in the opposite direction; that is by ascending the Missouri, crossing the Stony mountains, and descending the nearest river to the Pacific.' Capt. Meriwether Lewis, a connection by marriage of Gen. Washington, who was then stationed at Charlottesville, Va., on recruiting service, secured the appointment, and was to have had as sole companion the eminent French botanist, André Michaux, but when the latter had reached Kentucky he was recalled by the French Minister, then at Philadelphia, 'and thus failed the second attempt for exploring that region.'

1803. In 1803, two years after Jefferson had become President, in accordance with the suggestions contained in a confidential message from him, Congress so modified a pending act establishing trading houses with the Indian tribes as to extend its provisions to the Indians on the Missouri, and to authorize an exploration of the source of that river and of the best water communication from there to the Pacific, voting $2,500 for the expenses of the expedition.

Jefferson appointed to the command of this expedition Captain Meriwether Lewis, of whose special qualifications for this position he had had abundant proof during the preceding two years, during which he had served as his private secretary.

Lewis repaired at once to Philadelphia 'and placed himself under the tutorage of the distinguished professors of that place,' that he might be prepared to make the necessary scientific observations during his trip. At Lewis' suggestion Wm. Clark was associated with him in the direction, and for that purpose given a commission of captain in the army. Jefferson's detailed instructions of April, 1803, to guide his conduct after leaving the United States (the cession of Louisiana by France had not yet been

completed) afford a valuable insight into the conditions existing at that time, but time will not admit of any considerable quotation from them. He is to inform himself about the Rio Bravo, which flows into the Gulf of Mexico, and the Rio Colorado, which runs into the Gulf of California, which are 'understood to be the principal streams heading opposite to the Missouri and running southwardly.' Among the objects worthy of notice are mentioned: 'the remains and accounts of any animals which may be deemed rare or extinct; the mineral productions of every kind, but more particularly metals, limestone, pit-coal and saltpetre; salines and mineral waters, noting the temperature of the last and such circumstances as may indicate their character; volcanic appearances; climate,' etc.

Lewis left Washington on July 5, 1803, and did not reach there on his return until the middle of February, 1807. Meanwhile, after spending the winter of 1804–5 at the Mandan villages, in a bend of the Missouri about 40 miles above the present crossing of the N. P. R. R., at Bismarck, they had made a most successful trip across the mountains to the mouth of the Columbia river and back, an account of which is set forth in the admirable narrative first published in 1814 and recently republished with notes by Dr. Elliott Coues. This narrative shows a most intelligent observation of natural phenomena and makes mention of the existence of stone-coal along the upper Missouri river.

Schoolcraft's account of his visit in 1818 to St. Louis, then a city of 5,000 inhabitants, describes a museum established by Clark (then Governor of the Territory) containing a collection from his trip to the Rocky Mountains, including 'minerals, fossils, bones and other rare and interesting specimens,' and Nicollet in 1839 speaks of Cretaceous fossils brought in by Lewis and Clark from the upper Missouri river.

1805–7. Scarcely less remarkable were the explorations of Lieut. Zebulon M. Pike to the sources of the Mississippi in 1805, and in 1806–7 to the headwaters of the Arkansas, on the latter of which he made an unsuccessful attempt to climb the peak which has since born his name, and was finally taken from Santa Fé to Chihuahua as prisoner by the Mexican authorities.

Pike's expeditions were conducted under orders of Gen. Wilkinson, and were essentially military in their nature. A surgeon, Dr. Robinson accompanied them, but neither he nor Lieut. Pike have left any record of scientific observations in the narrative which was published in 1810.

1812. The war of 1812 now diverted the attention of government officials from Western explorations, but with the close of this war, when the treaty of Ghent had relieved the frontiers from the sanguinary Indian wars from which the people had been suffering, the prospect of a renewed emigration westward revived interest in exploration.

1820. J. C. Calhoun, Secretary of War under Monroe, a man of great intellectual grasp and energy of character, encouraged every means of acquiring a knowledge of the geography of the West. Two expeditions were organized under his orders in the year 1820, that of Maj. J. H. Long to the Rocky Mountains, and that of Gen. Lewis Cass along the south shore of Lake Superior to the sources of the Mississippi river.

To the former was attached Dr. Edwin James as botanist and geologist, who wrote the narative of the expedition, together with a report on the geological character of the country, which was published in 1823.

To Gen. Cass' expedition, an important part of whose object was to investigate the deposits of copper, lead and gypsum supposed to exist in the Northwest, a mineralogist was appointed in the person of H. R. Schoolcraft, a native of Albany Co., N. Y.,

who had distinguished himself by his investigations of the lead mines of Missouri.

GEOLOGY.

1820. Edwin James, who made the first geological report of a Western expedition, was a pupil of Amos Eaton. It was not until 1832 that Eaton adopted the system of identifying and correlating rock formations by means of their contained fossils. At the time of James' explorations geologists only attempted to distinguish rocks by their external lithological characters as belonging to one of the general great divisions of *primitive*, *transition*, *secondary* and *alluvions*, or recent deposits. Although James was evidently a shrewd observer, one would obtain but a confused idea of the structure of the country from his notes. Nevertheless he was one of the first, as Walcott remarks (Correlation Papers, Cambrian, p. 396) to attempt an extended correlation of geological formations of North America. He observed the general succession of rocks in the Appalachian, Ozark and Rocky Mountains, respectively, finding granites at the base in either case, and tracing the Carboniferous limestones through the two former.

He considered the red sandstones of the Appalachian and Lake Superior regions and of the Rocky Mountains to be of the same age and to probably correspond to the *old red sandstone* of Werner. He was the first white man to ascend Pike's Peak, and the ascent which was made from Manitou Springs, was by no means as easy as at the present day. He and his companion passed the night part way up the slope, where the ground was so steep that they had to prop themselves up by poles between two trees to keep from rolling down as they slept. James suggested the probable existence of artesian waters under the Great Plains, then called the Great American Desert. The material that Schoolcraft discovered in 1819 near Cape Girardeau, on the Mississippi River, and thought to represent the Chalk formation of Europe he found did not effervesce with acid, and classed it as a *native Argil.*

Schoolcraft, whose first government observations were made in the same year, devoted himself more particularly to the economic resources of the country. Already in 1818 he had spent three months in examining the lead mines in Missouri, and had extended his observations beyond the settlements into the Ozark Mountains. Determined to call the attention of the government to the value of its mines, he returned to New York via. New Orleans, and there published his book on the lead mines, which brought him to the attention of Mr. Calhoun, then Secretary of War, and resulted in his commission with the expedition of General Cass. His observations upon geology appear somewhat primitive and quaint, but are characterized by a shrewd common sense, as will be shown by a few quotations.

In speaking of the red sandstone on the south shore of Lake Superior near Grand Island, he says "the sandstone laps upon the granite and fits into its irregular indentations in a manner that shows it to have assumed that position subsequently to the upheaving of the country. Its horizontality is perfectly preserved even to the immediate point of contact. A mutual decomposition for a couple of inches into each rock has taken place. As to the geological age of the sandstone I possess no means of forming a decisive opinion. It consists of grains of quartz or sand united by a calcareous cement and colored by the red oxide of iron. In some places it imbeds pebbles of quartz of the size of a pigeon's egg, together with rounded masses of hornblende and other rocks, and it then resembles a pudding stone. It has no imbedded relics of the animal or vegetable kingdom so far

as observed, but this is not always conclusive of the age of the rock viewed at a given point, for it is known that these relics are never uniformly distributed throughout the substance of the rocks, even of the newest formations. Its position would indicate a near alliance to the old red sandstone. Werner has considered this rock in all situations as secondary. Bakewell places it in a class of transition rocks, in which he is followed by Maclure and Eaton. I am not prepared to decide upon the point * * *, and shall content myself in the present instance with a bare recital of the facts."

After the examination of the famous mass of native copper, variously estimated to weigh from one to five tons, which was the attraction of all travelers to the Lake Superior region, he says, in the course of his reflections upon its probable manner of occurrence, "there is reason to presume that the precious metals may be found in the northern regions of the American continent. Nothing appears more improbable than that the veins of silver ore that are so abundant in Mexico and the province of Texas are checked in their progress northward into Arkansas and Missouri by the effect of climate. This metal is known to be found in association only with certain limestones, schists and other rocks, and when these cease it is in vain to be sought. Other metals and minerals have their particular associations serving as a geognostic matrix, and hence rock strata may be considered as indexes to particular metals, minerals and ores, and the geologist is thus enabled to predict with considerable certainty from an examination of the exterior of the country whether it is metalliferous or not." In his 'Lead Mines of Missouri' he had mentioned the occurrence of chalk with flints, at Little Chain of Rocks, on the Mississippi River, which he says was worked commercially and found equal to foreign chalk. This was probably a bed of white pipe clay described by Shumard in 1871 (Missouri Geological Survey). He mentions the fluorspar of southern Illinois, the novaculite of the Arkansas Hot Springs, the red pipe stone of the upper Mississippi, coal in western Pennsylvania, Ohio, Virginia, Kentucky, Illinois and Missouri; also hydrogen gas or carburetted hydrogen at the Burning Spring on the Licking River. Pumice, he says, is brought down the Missouri River in the June floods, and probably comes from some volcanic mountain at the head of the river. A pseudo-pumice is also brought down which he supposes to have originated from the burning of beds of coal. He speaks of a mass of native iron, upwards of 3,000 pounds in weight, discovered on the banks of the Red River, and now (1819) in the collection of the New York Historical Society. "Its shape is irregular, inclining to oval form, its surface deeply indented and covered with oxide of iron. It is said to contain nickel, etc,"

1821. In 1821 Schoolcraft made another expedition with General Cass from Toledo across Ohio and Indiana, past the fluorspar deposits of southern Illinois, to St. Louis, returning by way of Chicago, an account of which was published as 'Travels in the Central Portions of the Mississippi Valley.'

1823. In 1823 a second expedition under Major Long was sent out by the War Department, which followed the Mississippi and Red River of the North to Lake Winnipeg, returning along the northern shore of Lake Superior. To this expedition Prof. William H. Keating, of Philadelphia, was attached as geologist, and published a narrative in two volumes in 1823 (George B. Whittaker, London). Keating in his narrative of the expedition, which started at Philadelphia, notes the evidences of old copper mining at South Mountain, in Maryland; the fact that coal mining is being

carried on at Cumberland, and at various points between there and Wheeling. He also remarks upon the Blowing Springs, and said he had no opportunity of testing whether they sent out gas or only air. He frequently mentions fossils observed, *encrinites* and *productus*, but does not attempt to define geological horizons by them, but only to judge whether the limestones were primitive (without organic life), transition or secondary.

1832. In 1832 Mr. Schoolcraft, under a commission from the government, commanded an expedition to the country about the sources of the Mississippi River, which he discovered took its rise in Lake Itasca, a narrative of which was published in 1834, and again enlarged in 1855.

1832–6. The expeditions of Capt. Bonneville, U. S. A., made famous by Irving's two narratives, were not, strictly speaking, government expeditions, being conducted under the auspices of the American Fur Trading Company, while he was on leave of absence from the army. No geologist was attached to the expedition, but the geographical results were very important, as by them was first determined the enclosed nature of the great interior basin, which had hitherto been supposed to have an outlet to the Pacific Ocean through the mythical Rio Buenaventura.

1834–5. G. W. Featherstonaugh, of whose origin little seems to be known except that he was a foreign traveler, was employed by Lewis Cass as Secretary of War, during the years 1834–5, to make geological investigations in the Ozark Mountains and along the elevated plateau separating the Missouri River from the St. Peter, or Minnesota River, known as the Coteau des Prairies. The report upon the first of these regions was published in 1835, and that upon the second in 1836.

In Featherstonaugh's time, light was commencing to come to the minds of American geologists out of the obscurity of ideas concerning the existing division of rocks into primitive, transition and secondary. It was already practically recognized that different horizons could be correlated in different parts of the world more safely and accurately by fossils than by lithological characters. Featherstonaugh found Carboniferous fossils widespread throughout the United States, on which he makes the following comments: "Although these fossils are not identically the same as their equivalents in Europe, yet many of them are strictly so; and in all cases I would assert the generic resemblances to be stronger than the specific differences. On this continent, where the Carboniferous limestones extend uninterruptedly for more than 1,000 miles, we find an equal amount of generic resemblance and specific difference, and it is certain that the specific difference between the most powerful species of living animals here and those in trans-Atlantic countries seems to be much greater than that which prevails among fossils of the two hemispheres." With regard to what had been generally known as primitive or inorganic rocks, however, he is not willing to accept the Wernerian or Plutonic theory of origin. Their differences with each other, except statuary marble, he remarks, result only from a difference in proportions of certain mineral constituents, which gives rise to the opinion that they had a common origin and "that they have all at some period been either ejected from central beds by the expansive power generated there, or that they have been great intumescing masses which on cooling have resolved themselves into various stages of crystallization, and that their varying products have been brought by fusion or solution into distinct central localities."

In his report Featherstonaugh publishes a section 12 feet long, extending from the Atlantic Ocean to Texas, which presents a

remarkably truthful representation, for the times, of the broader features of Appalachian structure. He calls attention to the fact that the littoral line on the Atlantic face of the mountains is found near the falls of the rivers. In his second report he gives a columnar section showing the correspondence of American and European formations, with average thickness of the latter, in which the Upper Cretaceous, Wealden, Oolite, and possibly the New Red sandstones are said to be deficient in the United States. In this section the Cambrian forms the base of the organic division. He remarks upon the rapid progress which geology has made in Europe during the past thirty years, and the increased interest manifested in this country as the result of his first report, giving rise to a movement among the States to undertake geological surveys. He says: "A geological map of the whole United States, where all the formations are exhibited on a large scale, and the most important deposits of fuel, metals and useful minerals be accurately laid down, would be a monument both useful and honorable to the country at home and abroad, and I trust the day is not distant when Congress will direct such a map to be constructed upon a scale commensurate with the undertaking."

1838. In 1838 J. N. Nicollet, a Savoyard naturalist, who had spent the last five years studying, at his own expense, the physical geography of the Southern and Mississippi Valley States, was commissioned by Col. Abert, of the Topographical Engineers, to make a map of the hydrographic basin of the Mississippi River.

In his report Nicollet remarks on the universal distribution of drift material, even on the summit of the Coteau, which had hitherto been called alluvium, but for which he prefers the term *Erratic deposites*. His principle contribution was the recognition of the fact that in that region there were limestones lower than the Carboniferous represented by fossils. He thought to have the Devonion in the lower part of the Mountain limestone, and he obtained Trenton fossils from the limestone around the Falls of St. Anthony. He also discovered the Cretaceous above Council Bluffs, and recognized its importance 'as destined to occupy a conspicuous place in the history of American geology.' Fort Pierre Chouteau was the upper limit of his explorations on the Missouri River. He got authentic accounts of pseudo-volcanoes caused by the spontaneous combustion of bituminous material within the rocks higher up the river, which he thinks may account for some, at least, of the pumice-like material that floats down the Missouri River.

1839. An important epoch in the study of western geology is marked by the work conducted under David Dale Owen, from 1839 to 1854. Dr. Owen was the son of Robert Owen, the social reformer, and at the same time a well-to-do manufacturer, who had settled in New Harmony, Ind., to carry out practically some of his social theories. David had received a liberal education abroad, both in Switzerland and Scotland, and had spent a year in London studying geology, in companionship with Henry B. Rogers. He later took the degree of M. D. in the Ohio Medical College in 1836. Having been appointed State Geologist of Indiana, he made a preliminary reconnaissance in 1837–8. The then Governor, James Whitcomb, became later United States Land Commissioner, and appointed Owen to make a survey of the Dubuque and Mineral Point land districts in Wisconsin and Iowa, under authority from Congress, in order to enable him to reserve from sale those sections containing mineral wealth. This work had to be done promptly, and it was commenced in September, 1839, and completed in February, 1840. He had 139 sub-agents and assistants under him, examining each sec-

tion under his instruction and supervision. Dr. John Locke was his geological assistant in this work. The determination of fossils of geological horizons was yet very imperfect, and the main conclusion arrived at was that the lead-bearing limestones were probably older than the Carboniferous.

1841. In 1841 the Wilkes Exploring Expedition, which, since 1838, had been cruising along the coasts and among the islands of the Pacific ocean, reached the coast of Oregon. Near the mouth of the Columbia river the ship Peacock on which was Prof. James D. Dana, the geologist of the Expedition, was wrecked, entailing the loss of all the latter's personal effects as well as many of his collections.

His loss was in the end, however, a gain to geological science, for on his trip across the Cascade mountains, and to San Francisco through the mountains of Oregon, past Mt. Shasta and down the valley of the Sacramento, he gained a personal knowledge of the geological conditions of the West, which was invaluable to him in later years when he was called upon to discuss the observations of later observers in the preparation of his Manual of Geology.

In his report upon the geology of the Wilkes Expedition, Dana calls attention to the fact that the slates of the Umpqua and Shasta regions resemble gold-bearing rocks of other regions, but it does not appear that he found actual evidence of the occurrence of gold.

He did observe the occurrence of sandstone dikes intersecting sandstones and shales near Astoria, and drew some interesting conclusions as to changes of level of the Coast region, which were further evidenced by the fiords along the coast and terraces along the river valleys; the latter he reasoned could not be explained by the current hypothesis that they were deposited in barrier lakes. As regards the whole Rocky Mountain region he concludes that it was probably in a great measure submerged until Cretaceous or later time.

1842–5. The three famous expeditions of Fremont were conducted in the years 1842, 1843–4 and 1845 respectively. They covered a very large part of the Cordilleran region, but unfortunately no geologist was attached to the expedition. Fremont himself, however, was a scientifically educated man, and had served under Nicollet in his expedition up the Missouri. His scientific notes, and the fossils and rocks collected, were afterwards worked up by Prof. James Hall.

Among the specimens thus brought and described were detected Niobrara limestones, upturned against the granites near Pike's Peak; green clays from the Eocene of the Bridger Basin, thought to resemble Cretaceous green sand; coal from the Muddy on the western edge of that basin, with fossil ferns which Hall said were not Carboniferous; fresh water shells from the Tertiary formations there and at the head of the Uinta River, on the east slope of the Wasatch Mountains; various eruptive rocks from the Snake River Valley, Blue Mountains and the Cascade Range; and a series of specimens from a bluff 700 feet high, which consisted largely of volcanic ash with fresh water fossil infusoria, which were probably formed of the Tertiary beds of the John Day River.

1846. In the spring of 1846 Dr. Wislizenus, 'a German by birth, but an American by choice,' as he characterizes himself, and evidently a man of wide scientific culture, undertook an examination into the geography and natural history of northern Mexico and Upper California at his private expense. While on his way west the war between the United States and Mexico broke out, and he was detained a prisoner for six months in the state of Chihuahua. Finding it impracticable to continue his work unaided, upon the arrival of the

American troops, he accepted the position of surgeon in the United States army, and finally returned with Col. Doniphan's command. His narrative, with scientific appendices, was printed by order of Congress. In it he notes Cretaceous rocks on the Great Plains, Cretaceous limestones with *Inoceramus* near Las Vegas, and the sandstones near Santa Fé 'thrown back at an angle of 100 degrees by the uplift of the granite.' Silurian limestones were seen near El Paso, and both Silurian and Cretaceous limestones around Chihuahua, Mexico. He does not appear, however, to have met with any outcrop of coal-bearing rocks. He remarks on a decadence of mining in Mexico and gives interesting statistics on the ancient silver and copper mines in the State of Chihuahua. In his report he gives what is called a geological map of the regions traversed, in which the occurrence of rocks of the different descriptions are indicated by words.

1847. In 1847 under the auspices of the United States Land office, of which James Whitcomb had now become Commissioner, David Dale Owen commenced his final survey of the Northwest Territory comprising parts of Wisconsin, Iowa, Minnesota and Nebraska. Although this work only incidentally extended into the region west of the Mississippi valley, it forms an important epoch in the geological history of the West, for it was the first systematically organized geological survey conducted under government authority, and by finally establishing geological horizons it has formed the basis of all later geological work in this region.

Dr. Owen had a large corps of scientific assistants and through them left a strong impress upon geological work in the Mississippi Valley. Among them were Richard Owen and E. T. Cox, who worked later in Indiana, A. H. Worthen in Illinois, Chas. Whittlesey at Lake Superior and J. G. Norwood in Kentucky.

After five years of field and one of office work, the report was published in two quarto volumes, with a large colored geological map, and a memoir on vertebrates by Dr. Joseph Leidy.

1847–1850. In this connection a brief mention may be made of the survey of the Lake Superior region, generally known as the Foster and Whitney Survey, because, although not carried on in the region under consideration, it had indirectly considerable influence on Western surveys.

Congress in March, 1847, had passed a law governing the sale of mineral lands in the Lake Superior land district which provided that the Secretary of the Treasury should cause a geological survey to be made previous to the offering of the lands for sale.

Dr. Chas. T. Jackson was appointed in the spring of 1847 to execute the survey, but resigned after two seasons' work, and the completion of the work was confided to J. W. Foster and J. D. Whitney, whose final reports were submitted in 1850 and 1851. They were assisted in their geological work by S. W. Hill and Edward Desor, the later an eminent Swiss geologist who had come to this country with Agassiz; while James Hall reported on their fossils and made valuable geological contributions to their final report. Whitney was not again in government employ, but played an important part in the development of its mineral resources, by his volume on the Metallic Wealth of the United States published in 1854, in which the theoretical views on ore deposits were far in advance of any published in this country or Europe, and which for many years was the only scientific treatise on the metallic mineral wealth of the country. He subsequently (1859–60) served on the Geological Survey of Wisconsin, making a special study of its lead mines, and in 1860 organized the State Geological Survey of California.

1849. In 1849 Dr. John Evans, under the

instruction of his chief, D. D. Owen, ascended the White River to the Bad Lands of Nebraska, along the southeast base of the Black Hills, and made collections of fossil vertebrates in the White River Miocene, whose existence had first been brought to notice through specimens sent in by the parties connected with the American Fur Trading Company. He also collected Mollusca in the Cretaceous beds from Fort Pierre up to a point 300 miles below the mouth of the Yellowstone, and traced the great lignite coal formation from there nearly to the Yellowstone River. The collections made at this time by Dr. Evans, together with those collected under the auspices of the Smithsonian in 1850 by T. A. Culbertson, and by Gen. Stuart Van Vliet of the United States army, were described in the Smithson contributions by Dr. Leidy in 1852. In this famous memoir the since well known forms *Titanotherium* and *Oreodon* were first described, and the age of the beds in which they occurred given as Eocene Tertiary.

1849-50. In 1849-50, under the orders of Col. Abert, of the Topographical Engineers, Lieut. Howard Stansbury made a survey of Great Salt Lake, and explored its valley and the surrounding mountains. No geologist was attached to his party, but his notes and fossils were reported upon by Prof. James Hall.

Stansbury noted the widespread occurrence of coal beds and recognized their future industrial importance, but does not appear to have obtained any data to determine their age. He brought in fossils from the Carboniferous limestone in Kansas, in Wyoming near Fort Laramie, and around Salt Lake Basin.

1851–52. In the summer of 1852 Captain R. B. Marcy and Brevet Captain George B. McClellan, of the United States Engineers, made an exploration in the Red River country from Fort Smith, Ark., to Fort Belknap, on the Brazos River, Texas. Dr. G. G. Shumard was appointed surgeon and naturalist to the expedition, and made collections which were submitted to various specialists for examination and study. Their reports are contained as appendices in Captain Marcy's report; published by act of Congress.

Hitchcock, the elder, reported on the specimens collected, except the fossils which were submitted to the latter's brother, Dr. B. F. Shumard, for identification. Carboniferous and Cretaceous forms were definitely determined, but Hitchcock was somewhat in doubt, owing to the imperfection of his data, whether the coals of the Brazos River were correctly assigned to the Carboniferous, on account of the loose texture of the rocks, and the fact that lignites of Tertiary and Cretaceous age were known to exist further north. The doubt is a reasonable one, for these coal beds are at the present day the most western workable coals of Carboniferous age known on the continent. Hitchcock remarks on the evidence shown in the canyons of the Llano Estacado, of the power of erosion, and shows that it was not necessary to resort, as Marcy was inclined to do, to the shattering of the crust by some great dynamic force to account for them.

In 1853 were commenced the numerous expeditions under the War Department to explore a route for a transcontinental railroad from the Mississippi Valley to the Pacific Ocean. To most of these parties a geologist or naturalist was attached, and the results of their observations, together with those of other naturalists, are found in the thirteen quarto volumes of the Pacific Railroad reports. They include Marcou, Newberry, Evans, Blake, Antisell, Gibbs and Schiel.

1853–4. Two reports made by Dr. John Evans to Gov. Stevens upon the geology of the northern route were lost in transit from the field to Washington. Dr. Evans died

at Washington in 1861 while at work upon his final report upon this region, which has consequently never been published.

To the expedition which explored the middle route across Colorado and Utah in 1853, under Capt. Gunnison, who was killed by Indians in Sevier Lake Valley, and through Wyoming, Utah and Nevada to California, in 1854, under Lieut. Beckwith, Dr. James Schiel was attached as surgeon and geologist. His report and Beckwith's narration contain scattered notes on the geology of the route, but no connected description.

Jules Marcou, who had come to this country from Switzerland with Agassiz, was the first geologist to study Western rock formations, who had had a field training in Europe. While his personal familiarity with different geological horizons in Europe enhanced the value of his field determinations, it also exposed him to the danger of laying too much stress in correlation upon mere physical resemblance. The route of the Whipple expedition, to which he was attached as geologist in 1853–4, followed the Arkansas and Canadian rivers from the mouth of the former to the source of the latter, and thence through New Mexico to Albuquerque; it then followed in a general way the general route of the Atlantic and Pacific Railroad to Los Angeles. His preliminary report was published in 1855. He also prepared a diagramatic section of the country from the Mississippi Valley to the Pacific Ocean; likewise a preliminary report upon the route followed by Capt. John Pope further south in Texas, made up from the notes and specimens collected by the latter. His claims as a geological discoverer rest upon the recognition of Carboniferous in Arkansas, the Permian and Carboniferous in New Mexico and Arizona, the Trias in Indian Territory, northern Texas and New Mexico. He thought also to have found the Jurassic, Neocomian and Chalk at different localities from New Mexico eastward. The geologists who have examined this field in later years and in greater detail have, in the light of all the geological knowledge that has accumulated since, assigned somewhat different ages to the beds described under the latter heads. This does not, however, detract from the value of Marcou's contribution to American geology, when one takes into consideration the circumstances under which his work was done and the little that was known of the geology of the West at the time.

Marcou did not make the official report upon his geological studies. When he was upon the point of embarking for Europe with his notes and collections, in order that, in working them up, he might be able to make comparisons with material in the museums abroad, they were seized by order of Jefferson Davis, then Secretary of War, and he was obliged to embark without them. His material was later worked up and the final report on the 35th parallel made by W. P. Blake, as official geologist of the expedition.

Blake's own observations were made as geologist in the expedition, under Lieutenants R. S. Williamson and J. G. Parke, in the summer of 1853, to determine the practicability of various routes from San Francisco through southern California to the mouth of the Gila River. The region is not one from which definite geological data could be obtained, the rocks, with the exception of recent and Tertiary formations, being barren of fossils and classed as metamorphic and eruptive. Eocene strata were recognized near San Diego, and Blake made interesting observations on desert phenomena, such as sand-polishing, prevailing west winds, etc. In economic geology he described the auriferous gravels and hydraulic washings, and concluded that the age of the formation of gold was contem-

poraneous with the uplift of the Coast Ranges and with the diorite or greenstone intrusions. His report was submitted in 1857.

1854–5. Dr. Thomas Antisell was geologist to Lieutenant Parke's expedition from San Francisco to Los Angeles through the Coast Ranges in 1854, and from the Pimas villages in Arizona, along the 32d parallel to the Organ Mountains, in New Mexico, in 1855. He considers the age of the Coast Ranges as post-Miocene, and notes the occurrence of bituminous deposits in southern California. He was influenced in his views on mountain ranges by Elie de Beaumont's theory of mountain uplift along the great circles, and endeavored to trace his systems in the West. He thus drew attention to the parallelism of the ridges in the great mountain ranges; the northwest trend in the Coast Ranges, the Sierra Nevada and the Arizona ranges, and the north and south trends in eastern New Mexico. He published colored sketch maps of sections of country passed through and indicated Carboniferous, Devonian and later rocks, but it appears that the only fossils he brought in were of Tertiary forms, and that his opinions as to age were based on the statements of other geologists and on lithological correspondence, and can be considered only as more or less well founded surmises.

1855. Dr. Newberry, as geologist of Williamson and Abbott's expedition from San Francisco to the Columbia River in the summer of 1855, noted the occurrence of Carboniferous and Cretaceous rocks in northern California, as evidenced by fossils collected by Dr. Trask, and that the Oregon coals of Coos Bay, Bellingham Bay and Vancouver Bay, probably of Tertiary (Miocene) age, rest on Cretaceous rocks, thus resembling the coals of the upper Missouri. He noted the existence of ancient glaciers at various points along the mountains, but gave no hints of active ones. He regarded the Sierras as of earlier upheaval than the Coast Ranges.

The contributions to the geology of the West in the period from 1855 to the Civil War had best be noted, not in strict chronological order, but geographically, taking first the southern region, next the interior, and finally the geology of the Great Plains.

1855–6. On the expedition to fix the boundary between Mexico and the United States under the treaty of 1854, which was conducted by Maj. W. H. Emory, Dr. C. C. Parry was geologist and botanist, and Arthur Schott, assistant geological observer.

In Maj. Emory's quarto report, first volume, are geological sketches of the country by Parry and Schott, with description of fossils by Hall and Conrad, and a general discussion of the geology of the region by James Hall. The report also contains a colored geological map of the Mississippi Valley and country to the west, which is the earliest colored geological map of the country west of the Mississippi published by the government.

The fossils described are mostly Tertiary and Cretaceous, and come in great measure from Texas. Upper Carboniferous limestones were identified at various points, and the presence of Silurian is suggested by Hall from a single fossil whose locality is not given. Hall discusses Marcou's section in northern Texas and New Mexico, and comes to the conclusion that the existence of any Mesozoic rocks in this region below the No. 1 Cretaceous, as determined by himself and Meek and Hayden, is not confirmed. The geological map prepared by him and Lesley is mainly interesting now as representing the blanks in the then geological knowledge of the interior of the Rocky Mountains. On the Great Plains his No. 1 Cretaceous included all that is now known as Trias, Jurassic and Lower Cretaceous, and was succeeded to the north by Upper

Cretaceous and Tertiary. Along a great part of the front of the Rocky Mountains and around the Black Hills was a strip of Upper Carboniferous and Upper Silurian separating the Cretaceous from the metamorphic nucleus. Likewise, along the face of several New Mexican ranges, in spots around Salt Lake and in the neighborhood of San Francisco Mountain, the Upper Carboniferous was represented. With this exception all the Western mountain region was indicated as metamorphic or unknown, as far as the Pacific Ocean, except for large areas of igneous and Quarternary in northern California and Oregon.

1857. To the expedition of Lieutenant J. C. Ives, sent out in the autumn of 1857 to explore the Colorado River from its mouth up to the head of navigation, Dr. J. S. Newberry was attached as geologist. A quarto report of this expedition was published by the government in 1861.

In this report Dr. Newberry summarizes the work that had been previously done in California, and makes the uplift of the Coast Ranges post-Miocene and probably later than the Sierra Nevada. His observations on the region of the Canyon of the Colorado are those of a trained geologist, and show a grasp of the broad conditions of structure of the Rocky Mountains much in advance of any previous observers. His published section of the rocks of the Grand Canyon, though not based in every instance upon direct lithological evidence, has not been essentially modified or improved by later observers up to the time of Walcott's investiation under the present Survey. The Algonkian formations between the Silurian and Archean do not occur in the region examined by him.

His general views on the structure of the mountains are seen in the following quotation (Ives Report, p. 47) :

"This much we can fairly infer from the observations already made on the geological structure of the far West, namely, that the outlines of the western part of the North American continent were approximately marked out from the earliest Paleozic times; not simply by areas of shallower water in an almost boundless ocean, but by groups of islands and broad continental surfaces of of dry land."

This remark was in opposition to the then generally received theory that the area of the Rocky and California mountains was till the Tertiary period occupied by an open sea.

1859. As geologist of the Macomb exploring expedition to the junction of the Grand and Green Rivers, Dr. Newberry collected much additional data on the geology of the plateau country. His report on the geology of the country, accompanied by a beautifully shaded topographical map made by Baron F. W. von Eggloffstein, was delayed by the confusion attending the Civil War, and was not published until 1876. It contains the following important additions to the geological knowledge of the region:

First, the determination of the Triassic age of the red sandstone by plant remains found at the copper mines of Abiquiu, New Mexico (Marcou's determination had been based on lithological evidence alone); second, the tracing of Upper and Middle Cretaceous formations along the south flanks of the San Juan into the upper Colorado Basin, and making a section of 6,000 feet of rocks from the Carboniferous to Cretaceous, inclusive; third, the finding of Saurian remains in the Canyon Pintado in the beds below the No. 1 Cretaceous, which, doubtless, represent the Atlantosaurus beds, since made famous by Marsh. Finally, although he only skirted around the isolated laccolitic mountains of that region, he shows a remarkable prescience in his remark upon the Sierra Abajo, that it has the appearance of a trachytic core pushed up through and uplifting Cretaceous strata.

In 1859 Capt. J. H. Simpson, of the Topographical Engineers, was commissioned by Gen. Albert Sydney Johnson, then stationed at Camp Floyd, Utah, to explore a new wagon road from Salt Lake Valley to the base of the Sierra Nevada, near Carson, and also eastward as far as Fort Bridger, in Wyoming. Henry Engelmann, of St. Louis, was appointed geologist of this expedition.

He showed unusual industry in collecting fossils and minerals, but his observations are those of a mineralogist rather than those of a stratigraphic geologist. From the determination of his fossils by Meek, it appears that he obtained Devonian forms in central Nevada, and lower Carboniferous in the Oquirrh Mountains of Utah, near Camp Floyd, thus determining lower horizons than had hitherto been known to exist west of the Missouri River.

Fossil-bearing Jurassic limestones were observed on the La Bonté Creek, near Fort Laramie, and on the western slope of the Wasatch, and a collection of fresh water fossils was made at the locality on Bear river, which for so many years puzzled paleontologists and geologists.

The probable Cretaceous age of the coal beds of the Weber Valley, and the San-Pete fields to the south was determined. He notes the widespread occurrence of eruptive rocks, especially through Nevada, but his lithological determinations, such for instance as that of phonolite, have to be accepted with some reservation, though they show more careful and intelligent study of their mineralogical composition than have been given by earlier geologists.

As his report was not published until 1875 (16 years after the observations were made), the facts determined were not available for the guidance of later explorers in in that region.

1853–6. The geology of the Great Plains is inseparably connected with the names of Meek and Hayden. They were first sent to the Bad Lands of Missouri by Prof. James Hall, in 1853. Hayden spent the summers of the two following years traveling with parties of the American Fur Trading Company, thus exploring geologically the Missouri Basin. He wrote a brief sketch on the geology of this region for Lieutenant Warren's 'Report on Explorations in the Dacota Country.' In this he mentions the Tertiary basin of White River, in which the great discoveries of vertebrate remains were then being made, the Bad Lands of the Judith River, and the great lignite basin extending from the mouth of the Cannon Ball River to that of the Muscleshell River.

1857. In 1857 he accompanied Lieutenant Warren to the Black Hills of Dakota, and submitted a report in November, 1858. (Reprinted in 1875, in Lieutenant Warren's 'Preliminary report on explorations in Nebraska and Dakota.') In this he gives a complete column of geological formations, as known in Kansas and Nebraska Territories, from the Potsdam upwards. The Potsdam had been detected by lower Silurian forms in the Black Hills. This and the discovery of the marine Jura, well represented by fossil forms, with fresh water beds just above them, which he was doubtful whether to place with the Jura or Cretaceous, and the discovery of vertebrates near the mouth of Judith River, which Dr. Leidy thought might be Wealden, constitute the important discoveries outlined in this report. The assumed existence of Devonian beds is evidently based on a mere conjecture which has not been substantiated.

1858. The summer of 1858 was spent by Meek and Hayden in making collections of fossils in Kansas Territory, and in 1859–60 Dr. Hayden served as geologist to the expedition of Captain W. F. Raynolds to the headwaters of the Missouri and Yellowstone Rivers. His geological work was in-

terrupted by the war, in which he served as surgeon in the army, and his report was submitted in 1867, but not printed until 1869. With this was a geological coloring of Raynold's topographical map, which gives in a very generalized form the current ideas with regard to the geology of the country east of the mountains. It shows the anticlinal structure observed in the Black Hills extended to all the ranges facing the plains. In the interior, granites, igneous and metamorphic rocks are all grouped under one color, and no formation between Carboniferous and Potsdam is recognized. The age of the coal-bearing beds is given as Tertiary.

1867. I will mention here the contributions of John LeConte in 1867, though not strictly in chronological order, nor under government auspices, yet they were part of the general scheme of exploration of the country for the projected Pacific railroad. He was attached to the party of Gen. W. W. Wright, of the eastern division of the Union Pacific Railroad, which was exploring various routes from Fort Lyon, Kansas, to Fort Craig, New Mexico. He made a more careful study of the coal-bearing rocks than had yet been made, and maintained his belief in spite of the evidence of fossil plants as interpreted by Lesquereux, that they were Cretaceous rather than Tertiary, a belief founded mainly on Molluscan fossils of Cretaceous age found by him in association with the coal beds, but in part also on a reasoning that the development of plant life in this country had not been strictly contemporaneous with that of Europe. On this point he says: "The difference between the plants of our early Cretaceous and those of the Middle Tertiary could be ascertained only by the aid of the stratigraphy of the region, and we have no right from a few resemblances in vegetables to infer the synchronism either of the Western lignite beds with each other, or any of them with the European Eocene and Miocene, except when supported by lithological evidence from animal remains.

"It would therefore appear plausible, in the absence of more direct evidence, to believe that since the introduction of dicotyledons in large numbers in our early Cretaceous there has not been any great change in the types of structure; and that such changes, while following in general plan those introduced on the eastern continent during this period, have not been synchronous with them."

He noted several unconformities in the beds, and presented a history of the orographic growth of the Great Plains in Mesozoic time, which shows a remarkably philosophical interpretation of the facts then known. His idea was that the region grew, by a series of gradual elevations connecting Paleozoic islands, into one landmass; that a great peninsula was developed running eastward from the Rocky Mountains and contracting the intercontinental Cretaceous ocean. Thus by the end of the Middle Cretaceous this ocean was divided into two gulfs, a northern and a southern, in which toward the end of that period the faunas became quite different. Finally, independent shallow basins were formed in which conditions for coal accumulation prevailed.

S. F. EMMONS.
U. S. GEOLOGICAL SURVEY.

(To be concluded.)

PHASES IN JAMAICAN NATURAL HISTORY.

PROF. J. E. DUERDEN,* Curator of the Museum of the Institute of Jamaica, has recently published an article which gives new and interesting data concerning the results of the introduction of the Mongoose to the Island.

* Contributions to the Natural History of Jamaica. By J. E. Duerden, Curator of the Museum of the Institute of Jamaica. Kingston, November, 1896.